LESSONS-LEARNED, CRASH FIRE RESCUE TRAINING FACILITIES

Gary D. Robinson
CESPA-ET-EF
(505)342-3398

INTRODUCTION

This paper discusses the general use and functionality of the crash fire rescue training facilities. It also discusses the fire training facility design and performance, the problems encountered with the design and the revisions made to alleviate the problems.

BACKGROUND

The Crash Fire Rescue Training Facilities (CFRTF)are aircraft crash mock-up that use the liquified petroleum gas (lpg) propane to simulate ensuing fires. All of the facilities erected after 1992 are based on a standardized aircraft crash fire rescue training facility design provided by the Air Force. The standard design was developed so that all fire fighting personnel will receive the same training, regardless of the training facility location. The design contains all of the basic components required to simulate the different types and locations of fires observed from a crashed aircraft.

BASIC COMPONENTS

The basic design components of the crash fire rescue training facilities specified in the standard design are as indicated in figure 1. The components consists of an aircraft mock-up located within a circular burn pit, an lpg storage tank and fuel piping distribution system, electrical power and control systems, a water conservation pond, and a central control/observation tower.

AIRCRAFT MOCK-UP

The aircraft mock-up consists of a 3.66 m (12 ft.) diameter corrugated steel fuselage and rolled plate steel nose and tail sections, a low right wing section, a high left wing section with two engines, and a high tail section with a single engine. The inside of the mock-up contains grated flooring for general circulation with an elevated cockpit area. Openings in the mock-up include 2 doors on each side, a cargo opening at the tail section, and window openings at the cockpit and on the sides of the fuselage. The mock-up is approximately 23.8 m (78 ft.) in length

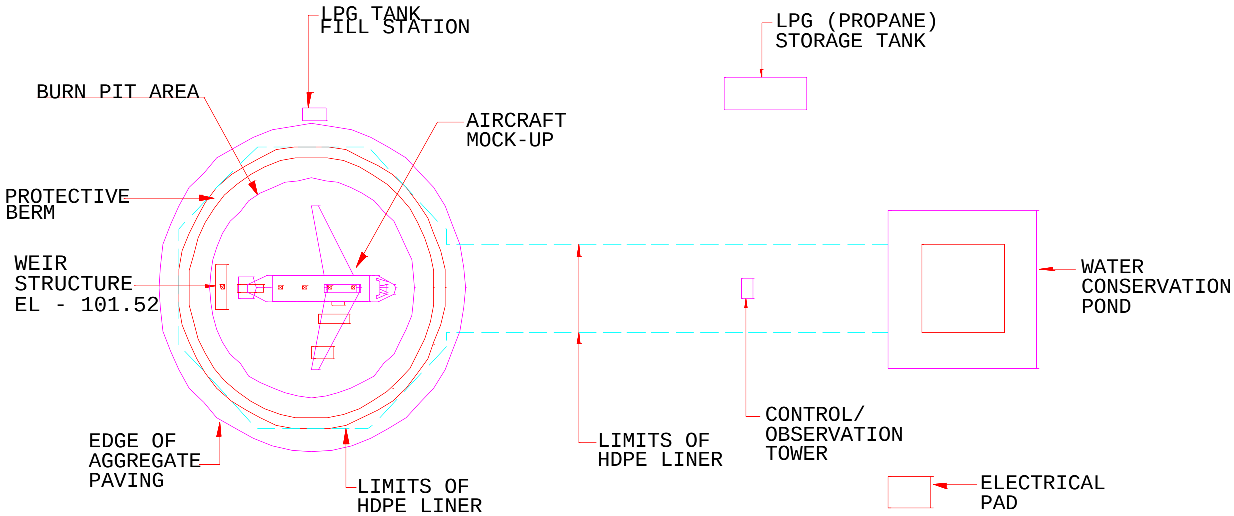

FIGURE 1. TYPICAL CRASH FIRE RESCUE TRAINING FACILITY DESIGN COMPONENTS

with a total wing span of 22.9 m (75 ft.). Access inside of the mock-up is achieved from the low wing section of the plane. The mock-up aircraft is suspended from an internal frame structure which rests on six columns with large bearing plates and two additional supports are provided for each wing section.

BURN PIT

The burn pit area is approximately 36.6 m (120 ft.) in diameter and 1.22 m (4 ft.) deep and is protected by a 304.8 mm (1 ft.) high berm. An 80 mil high density polyethylene (hdpe) liner is located at the bottom of the pit to contain water and products of combustion which may be harmful to the environment. The area just outside of the burn pit is compacted aggregate paving. The area in the burn pit below the mock-up is filled with compacted crushed angular rock that is used for maneuverability when the burn pit is filled with water. The pit contains a drainage weir which is used to drain the water level in the pit to prevent algae and to alleviate the occurrence of breeding insects. The drainage weir gravity drains to the water conservation pond or to a lift station through a 50 mm (2") pipe.

LP-GAS STORAGE TANK AND PIPING DISTRIBUTION SYSTEM

A horizontal aboveground steel lpg storage tank with a minimum volume of 37,854 Liters (10,000 gal.) is used to supply propane to the facility. Schedule 80 black steel piping is used to convey the propane liquid and gas mixture from the storage tank to the lpg distribution manifold located at the control tower. The piping off of the distribution manifold is routed down the tower, underground to the burn pit and then to each respective fuel burner assembly.

Four types of burner assemblies are utilized in and around the mock-up. They are interior, engine, exterior and ground burner assemblies. Interior burner assemblies are located in the cockpit, battery compartment, passenger (pax) compartment and cargo compartment (figure 2). The exterior burner assemblies (figure 3)

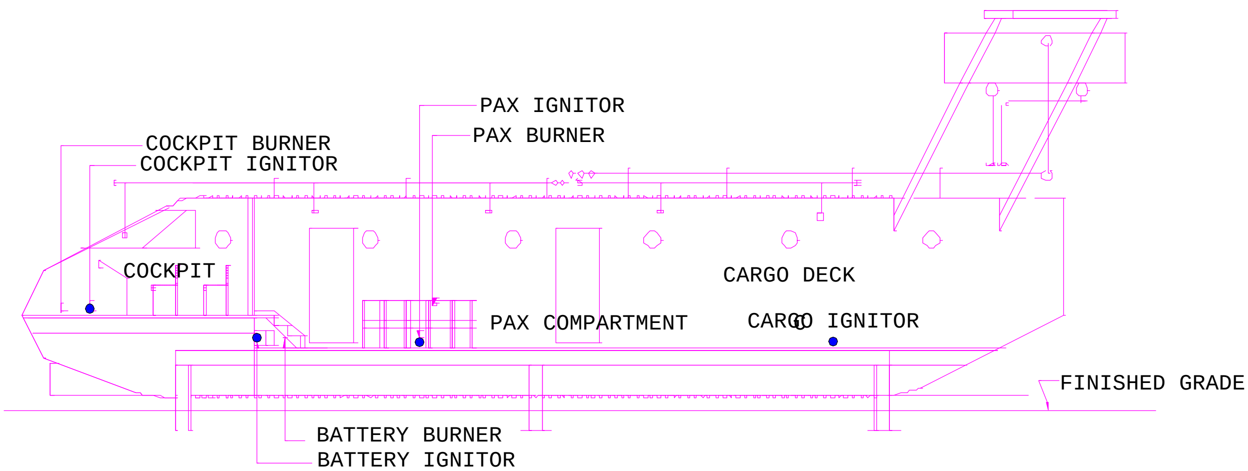

FIGURE 2. INTERIOR BURNER AND IGNITOR LOCATIONS

are located at the auxiliary package unit (apu) and wheel well compartments. The engine burner assemblies are located in the two high wing engines and in the high tail engine. The ground burner assemblies are located at the front and rear of the mock-up and under the high and low wings.

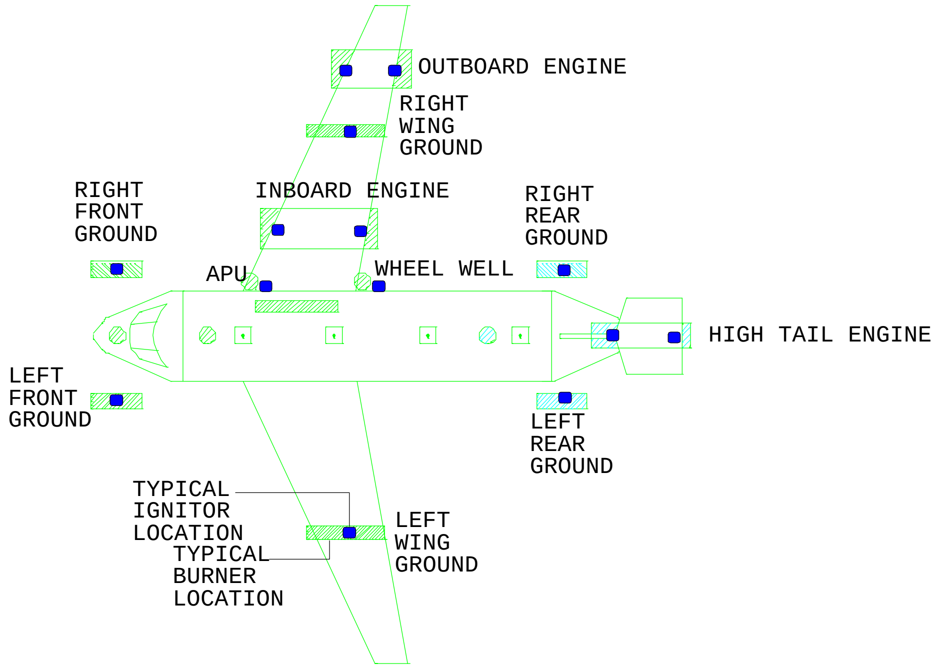

FIGURE 3. EXTERIOR BURNER AND IGNITOR LOCATIONS

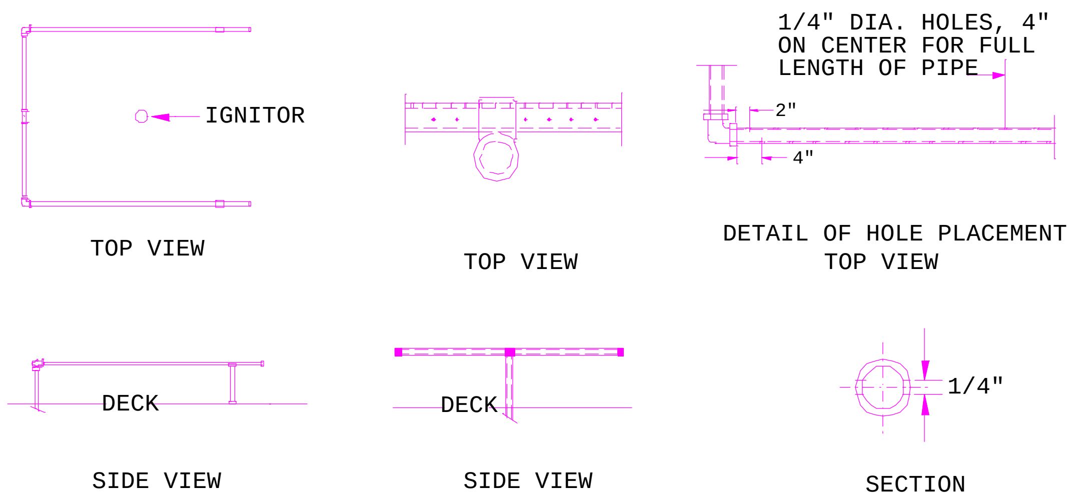

FIG. 4a - LINEAR BURNER CONFIGURATION USED AT COCKPIT AND CARGO LOCATIONS

FIG. 4b - LINEAR BURNER CONFIGURATION USED AT BATTERY PAX AND WING ENGINE LOCATIONS

FIG. 4c - TYPICAL LINEAR BURNER FUEL SUPPLY HOLE PLACEMENT

FIGURE 4. TYPICAL LINEAR BURNER CONFIGURATIONS

All burner assemblies are formed from schedule 80 black steel piping (figure 4). The interior burner assemblies consists of a single or dual parallel piped fuel distribution manifold with 8 mm (1/4") perforations (figures 4a and 4b). Engine burners consist of a single piped fuel distribution manifold with 8 mm (1/4") perforations (figure 4b). Fuel from the burner is dispersed into water within each engine which produces a fire effect which covers a larger surface area that the linear burner pipe can not provide alone.

Each ground burner assembly consists of four steel parallel piped fuel distribution manifolds with 8 mm (1/4") perforations along the length of the pipe (figure 5). Each ground burner is submersed just below the water level in the burn pit. This creates a pooling effect which distributes the fuel outward of the burner and creates fires that cover a greater surface area. The ground burners locations allow fire fighters to experience the simulation of a crashed aircraft that has been totally enveloped in flames.

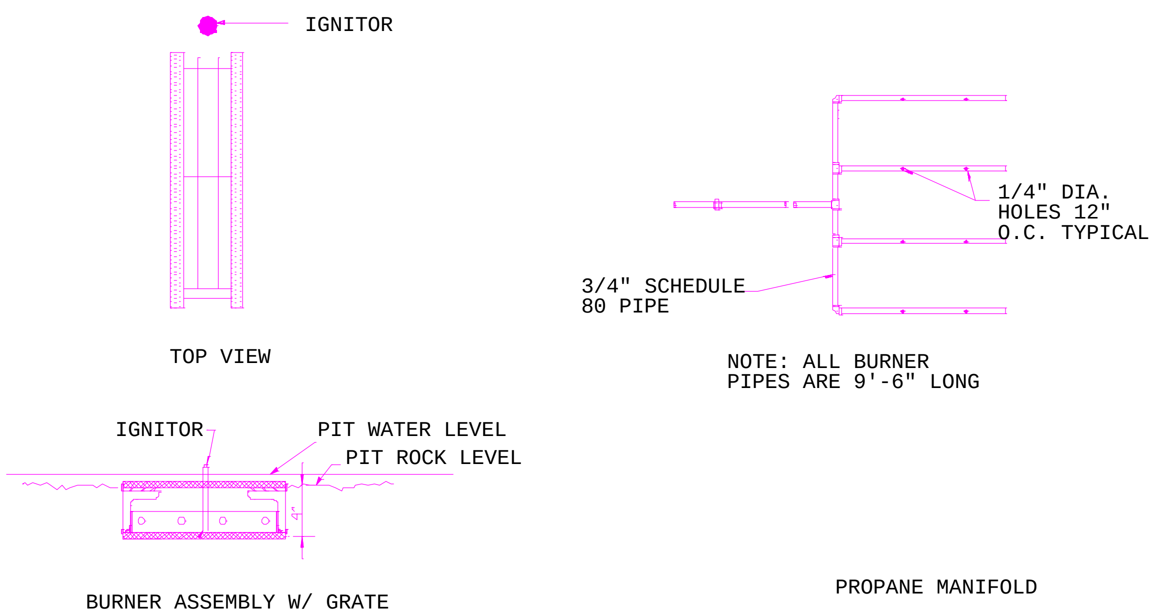

FIGURE 5. TYPICAL GROUND BURNER CONFIGURATION

ELECTRICAL POWER AND CONTROL SYSTEM

The electrical systems consist of general site power for lighting, site transformer, individual high voltage ignitor transformers, equipment disconnect switches, ignitor and lighting control switches, pump control switches and lp-gas driven generators at some remote locations. All electrical components located within fifteen feet of lp-gas relief vents are required explosion proof rated, however by piping the relief vent lines fifteen feet from the electrical components, the expense of installing explosion proof type devices was avoided.

Each electrical ignitor conduit located within the burn pit is encased in a water jacket assembly (figure 6). The water jacket assembly consists of high voltage ignitor wiring within schedule 40 conduit encased in 101.4 mm (4") diameter schedule 80 black steel water piping and a 101.4 mm (4") ignitor assembly encased in a 254 mm (10") diameter schedule 80 black steel water piping. The water jacket assemblies prevent the electrical wiring from being damaged by the intense heat generated during training exercises.

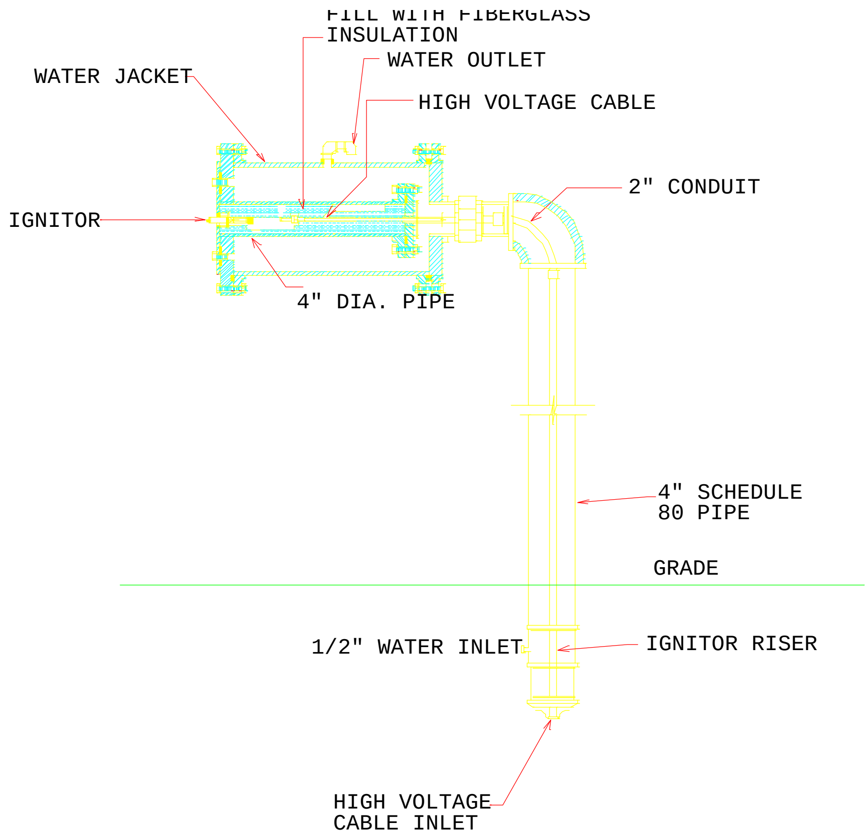

FIGURE 6. TYPICAL IGNITOR WATER JACKET ASSEMBLY

CONTROL/OBSERVATION TOWER

The control tower is a 3.66 to 6.10 m (12 to 20 ft.) steel structure with an observation deck at 2.81 m (9 ft.) above grade that faces the burn pit. The tower contains the emergency shut down controls and all of the fuel, water and electrical control valves and switches (figure 8).

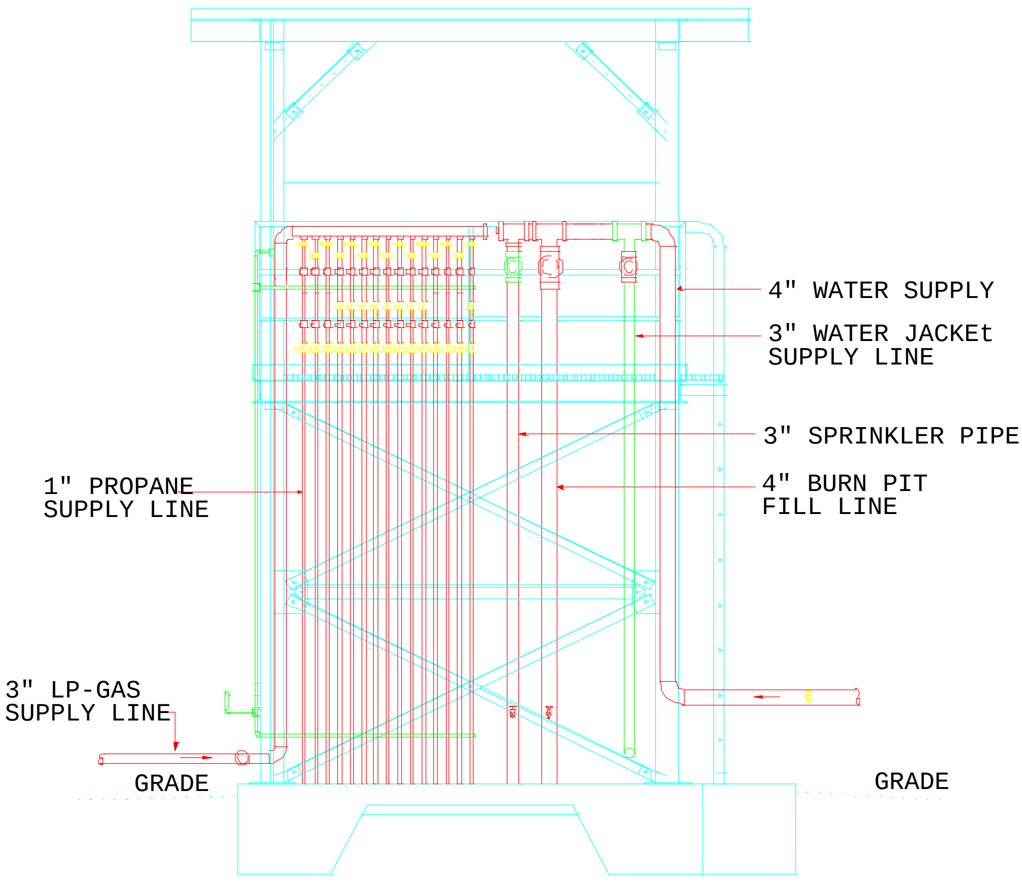

FIGURE 7. CFRTF CONTROL/OBSERVATION TOWER

WATER CONSERVATION POND

An approximately 340 m^3 (12,000 ft^3) in ground water conservation (holding) pond is utilized to store water to be used in the burn pit. The entire pond is formed using an 80 mil hdpe liner. The pond is designed to supply water to the burn pit functions and to receive the discharge from the burn pit drain lines after training exercise have been completed. A submersible pump within the pond is used to supply water to the water distribution manifold at the control tower. The water is then routed to burn pit. To offset the effects of evaporation or having to truck water into the facilities, make-up water for the pond is provided from either a yard hydrant or a fire hydrant located near the pond.

DESIGN CONCEPT

The basis of the crash fire rescue training facilities is to provide a realistic atmosphere from which "hands on" aircraft crash rescue and fire fighting training can be accomplished in a safe and controlled manner. The propane and electrical systems at the facilities are designed so that a single operator located at the control tower controls and oversees all training activities being performed. From the tower, the operator controls the locations, durations, and the intensities of the fires within the burn pit. The fuel burner system is designed so that the fires in the pit are not capable of being extinguished by the fire fighters. All fires will be shut down by the operator once the fire fighters have learned the proper fire fighting techniques and the training instructor is satisfied with their performance. The operator also controls all the fire simulation support functions such as the water supply system and the emergency shut down system.

SYSTEMS OPERATION

WATER DISTRIBUTION SYSTEM

Prior to starting the fires within the burn pit, the burn pit fill control valve is opened and the submersible pump located within the water conservation pond is activated. The pump distributes the water through a 100 mm (4") manifold located in the burn pit with outlet slots located throughout the length of the pipe. Once the burn pit is filled up to the level of the top of the drainage weir, the fill water supply valve is closed, the ignitor water jacket supply valve is opened and the running fuel fire supply pump is activated. Upon verification that all water systems are properly functioning, the facility is ready to begin fire training procedures. After training procedures are completed, the water distribution pumps are deactivated, all water supply valves are closed, and the drainage weir inlet and outlet valves are opened allowing the burn pit to drain.

PROPANE FUEL DISTRIBUTION SYSTEM

The fuel distribution system is designed to provide a minimum of fifteen individual burner fires within and outside of the aircraft mock-up. Each burner assembly is controlled from the tower. Prior to supplying propane to the respective burner, the corresponding electrical spark type ignitor is activated and verified operable. When the ignitor is activated, a solenoid valve located in the fuel line opens and remains open until the ignitor is reset. The operator then opens the manual fuel control valve and the burner fire is ignited. The operator adjusts the height of the burner fire with the control valve until the desired fire is achieved. Each burner assembly is activated similarly and depending on the training objectives, numerous burners may be in activation simultaneously.

ELECTRICAL IGNITOR CONTROL SYSTEM

The fires within burn pit are ignited by high temperature, spark type ignitors (Figure 4). All ground and interior burners are ignited by a single ignitor assembly while each of the wing engine burners are ignited by two ignitors. Each single ignitor and each set of ignitors are individually controlled from a switch located at the control tower. All of the interior and engine compartment burner ignitors have fixed "on-off" type manual ignitor control switches while the ground burners have momentary "on-off" type manual control switches.

EMERGENCY SHUT-DOWN SYSTEM

The emergency shut down system consists of nitrogen operated pneumatic lp-gas shut-off valves located in the burn pit in each of the fifteen lp gas lines at approximately 76.2 mm (3 ft.) from the base of each burner riser. Five electric pilot valves at the control tower which are connected to the emergency shut down button are utilized to control the pneumatic valves in the burn pit in the burn pit. Pneumatic piping from the control tower to the burn pit is routed underground in a service trench. When an emergency arises, the emergency shut-down system push button is activated and all pneumatic valves within the burn pit are closed. The lp-gas solenoid valves are closed and all electrical ignitors are deactivated. The system remains inactive until the shut-down system button is reset.

DESIGN DEFICIENCIES AND MODIFICATIONS

After the standard design drawings were distributed for use and various crash fire training facilities had been erected, several revisions to the design were required to upgrade each of the facilities to the safety and functional standards required by the Air Force. Primary revisions included adding an emergency shut-down system, revising the existing control buttons, adding an ignitor water jacket cooling system, and revising the aboveground burner assemblies. Other revisions that were made on a site by site case included providing an lpg storage tank with a capacity of at least 37,854 Liters(10,000 gal.), revising and adding burner shields, replacing aboveground schedule 40 black steel lp-gas distribution piping with schedule 80 black steel piping, replacing pea size gravel within burn pit with 1 1/2" to 2 1/2" crushed angular rock, adding a cover to control tower and upgrading lift station pumping capacities.

EMERGENCY SHUT-DOWN SYSTEM

During the testing of several of the training facilities, it was observed that the burners continued to produce a fire for periods of thirty seconds or more after the fuel control valves were closed. This effect was caused because the fuel that remained in approximately 61 m (200 ft.)of the lp-gas distribution piping located between the fuel control valve at the control stand and the burner assemblies in the burn pit continued to be released until totally depleted. The emergency fuel shut-down system was incorporated to provide instantaneous fuel shut-off for whenever an emergency arises.

LP-GAS BURNERS AND SHIELDS

Initially all the burner assemblies, excluding the ground burners, utilized spray type nozzles to simulate the fires at each respective location. When tested, the nozzles created a fire pattern similar to that created by a small flame thrower. The effects from the nozzles produced very little smoke and an almost invisible flame. These fires were not comparable to the fires attained in an actual aircraft fire and needed to be revised. In order to produce a more realistic type fire and smoke simulation, the linear type burners were adopted.

Several of the burners were designed with small shields which were to prevent the burner fires from being extinguished by the fire fighters. While testing the facilities, the fires were being extinguished by the hose streams because the burners were not protected on all sides from which the fire fighter could approach. When the fires became extinguished, propane fuel continued to flow. This caused a safety concern and in order to insure that explosion from the accumulation of propane did not occur within the aircraft mock-up, plate steel shields were added or revised at the interior burner locations so that the fire fighters hose streams could not come into direct contact with the burner and ignitor assemblies, regardless of their angle of attach.

IGNITOR WATER JACKETS

The electrical wiring serving the burner ignitor assemblies were initially encased in schedule 40 steel conduit and routed to each ignitor. During testing on several of the facilities, the ignitor wiring became frayed from the intense heat produced from the burner fires and consequently the ignitors became inoperable. In order to protect the wiring and ignitors from the heat, ignitor water jackets were designed. The water jackets consists of the electrical wiring within conduit encased in 4" to 10" diameter piping that is sealed at the base of each electrical riser and at the location of the ignitor spark mechanism (spark plug). An inlet at the base of the riser and an outlet at the ignitor encasement are installed and water is circulated through the encasement to prevent the wiring from being overheated. The water piping system is designed to constantly flow approximately 5 gpm through the each of the water jackets while training is being performed.

ELECTRICAL IGNITOR CONTROLS

The initial crash fire training facility design documents provided for the installation of ignitor push button type controls for each of the burner assemblies in the burn pit. However, the plans did not provide any guidance on the order and location of the controls. During the testing of several of the facilities, the operators were having trouble coordinating the ignitor controls with the manual fuel control valves. Some of the valves and ignitor control switches were out of reach of each other and therefore required more than one person to operate. In order to alleviate the problem and to provide precise coordination between the ignitor controls and the fuel supply controls to each burner, the electrical ignitor switches were rearranged and relabeled to match the order of the burner propane supply piping. This allowed a single operator to control all fueling control functions without losing direct sight of the training events.

CONCLUSION

The crash fire rescue training facilities constructed from the Air Force standard design initially contained several design and safety deficiencies which prohibited the fire training personnel from utilizing the facilities until the necessary modifications were made. Through the testing of several of the facilities and feedback from design and construction personnel, the deficiencies were identified and corrections were established. The corrections were incorporated into the construction documents and modifications are currently being performed or have recently been completed. Once each facility is tested and approved by the Air Force, the fire fighting personnel will be able to utilize the facilities.

AUTHOR'S ADDRESS: U.S. Army Corps of Engineers
Albuquerque District
4101 Jefferson Plaza NE
Albuquerque, NM 87109
CORPSMAIL: CESPA-ETEF